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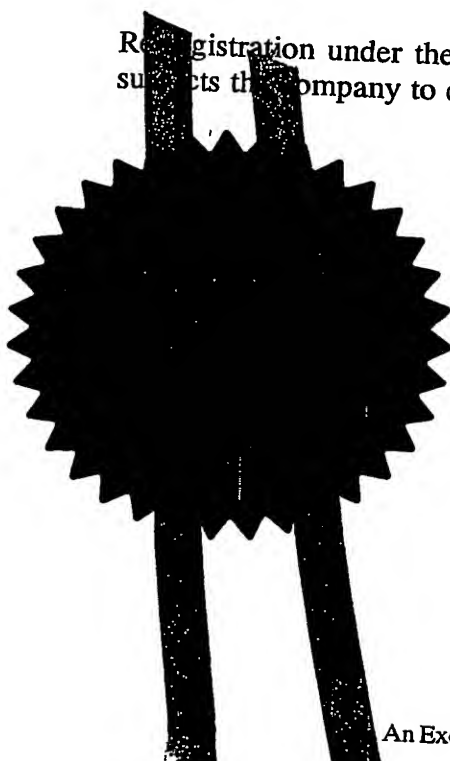
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sps.2845.uk.dka 07APR03 E797927-1 D10002
P01/7700 0.00-0307825.0

2. Patent application number
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0307825.0

3. Full name, address and postcode of the or of each applicant (underline all surnames)

Specialised Petroleum Services Group Limited
Arnhall Business Park
Westhill
ABERDEEN
AB32 6TQ

Patents ADP number (if you know it)

If the applicant is a corporate body, give the country/state of its incorporation

United Kingdom

4. Title of the invention

8460784002

Mechanism for Actuation of a Downhole Tool

5. Name of your agent (if you have one)

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

Kennedys Patent Agency Limited
Queens House, Floor 5
29 St Vincent Place
GLASGOW
G1 2DT

Patents ADP number (if you know it)

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Number of earlier application

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1 Mechanism for Actuation of a Downhole Tool

2

3 The present invention relates to downhole tools as used
4 in the oil and gas industry and in particular, though not
5 exclusively, to a mechanism for moving a sleeve in a
6 downhole tool by dropping a steel ball onto an expandable
7 ball seat.

8

9 While many downhole tools operate continuously through a
10 well bore e.g. scrapers and brushes as disclosed in US
11 6,227,291, it is more desirable to provide a tool which
12 performs a function only when it has reached a preferred
13 location within a well bore. An example of such a tool
14 would be a circulation tool as disclosed in WO 02/061236.
15 The tool provides a cleaning action on the walls of the
16 casing or lining of the well bore. The cleaning action is
17 only required after the casing has been brushed or
18 scraped and thus the tool is designed to be selectively
19 actuated in the well bore. Such tools provide the
20 advantage of allowing an operator to mount a number of
21 tools on a single work string and operate them
22 individually on a single trip in to the well bore. This
23 saves significant time in making the well operational.

1 Tools which are selectively actuatable in a well bore
2 commonly operate by having an element which can be moved
3 relative to the tool when in the well bore. In the
4 circulation tool of WO 02/061236, the element is a sleeve
5 located in the cylindrical body of the tool. When run in
6 the well, the sleeve is held in a first position by one
7 or more shear screws. To actuate the tool, a drop ball
8 is released from the surface of the well through the work
9 string. On reaching the sleeve, the ball blocks the flow
10 of fluid through the tool and consequently pressure
11 builds up until the shear screws shear and the sleeve is
12 forced downwards. The movement of the sleeve is then
13 stopped when a lower ledge of the sleeve contacts a
14 shoulder on the internal surface of the tool body.
15

16 Such tools have a number of disadvantages. The tools are
17 generally limited to one actuatable movement. If two
18 sleeves are incorporated to overcome this, the shear
19 screws of the second sleeve can operate prematurely under
20 the shock created to shear the shear screws of the first
21 sleeve. Additionally, the reduced bore diameter of the
22 lower part also effects the flow rate achievable through
23 the tool.
24

25 One tool which has been developed to operate repeatedly
26 is that disclosed in US 4,889,199. This tool comprises a
27 tubular body having a radial port into which is located a
28 sleeve having a matching radial port. The sleeve is
29 slidably mounted and its action controlled from a
30 deformable drop ball biasing the sleeve against a spring.
31 Initially the spring biases the sleeve to a closed
32 position in which the ports are misaligned. The drop ball
33 causes the sleeve to move to a position where the ports

3

1 align due to a build up of pressure behind the ball, and
2 fluid is discharged radially through the ports. A small
3 steel ball is then dropped into the tool which seals the
4 radial ports and the consequential pressure build up
5 extrudes the deformable ball through the ball seat. The
6 steel ball will drop with the deformable ball and both
7 are retained in a ball catcher at the base of the tool.
8 When the balls drop together the spring biases the sleeve
9 back to the closed position and the tool can be operated
10 repeatedly.

11

12 A disadvantage of this tool is that it requires both a
13 deformable ball and a smaller metal ball to operate. Care
14 must then be taken to ensure the balls are dropped in the
15 correct order. The smaller metal ball must lodge in the
16 second, radial, outlet in order to stop flow and thus the
17 tool is restricted to having a single radial port. This
18 limits the amount of cleaning which can be performed. Yet
19 further is a disadvantage in that use of a rubber or
20 deformable ball is unreliable as the material can break
21 up or wear within the well bore.

22

23 It is an object of the present invention to provide an
24 actuation mechanism for a downhole tool which obviates or
25 mitigates at least some of the disadvantages of the prior
26 art.

27

28 It is a further object of at least one embodiment of the
29 present invention to provide an actuation mechanism to
30 move a sleeve within a downhole tool.

31

32 It is a yet further object of at least one embodiment of
33 the present invention to provide an actuation mechanism

4

1 for use in a downhole tool which is re-settable to allow
2 the tool to operate in a cyclic manner.

3

4 It is yet further object of at least one embodiment of
5 the present invention to provide a circulation tool which
6 can be operated repeatedly using a single ball.

7

8 According to a first aspect of the present invention
9 there is provided an actuation mechanism for a downhole
10 tool, the mechanism comprising a substantially
11 cylindrical body having a central bore running axially
12 therethrough, a sleeve located within the bore, the
13 sleeve including an expandable ball seat,
14 mechanical biasing means located between the sleeve and
15 the body to bias the sleeve in a first direction and a
16 ball, wherein the expandable ball seat releasably retains
17 the ball to prevent fluid flow through the sleeve and
18 cause the sleeve to move in the reverse direction
19 relative to the body.

20

21 When the ball is dropped in the body, the ball will
22 locate in the ball seat. The ball will block the fluid
23 path through the tool and consequently pressure will
24 build up on the ball by fluid travelling through the
25 body. This pressure will be sufficient to move the ball
26 and sleeve together against the mechanical bias and force
27 the sleeve in the reverse direction. The movement of the
28 sleeve actuates the tool. When the limit of the bias is
29 reached, increased pressure will expand the expandable
30 ball seat and release the ball. On release of the ball,
31 pressure drops and the sleeve is biased in the first
32 direction back to its original position.

33

5

1 Preferably the mechanical bias is a strong spring. The
2 spring may be helical, conical or the like. A strong
3 string will prevent the sleeve moving in the reverse
4 direction by fluid flow in the central bore.

5

6 Preferably the expandable ball seat includes a part
7 conical surface having an aperture therethrough.

8 Advantageously the aperture has a diameter less than a
9 diameter of the ball. Preferably the ball seat is made of
10 a flexible material, so that at a predetermined pressure
11 it flexes to release the ball. Advantageously the ball
12 seat is made of a metal so that the seat is not prone to
13 wear during use. The ball seat may comprise a spring such
14 as a disc spring.

15

16 Optionally the ball seat may be of a layered structure..
17 Preferably the layered structure comprises a plurality of
18 disc springs. Advantageously the disc springs are
19 arranged oppositely in the structure to provide flex.

20

21 Preferably the ball is spherical. More preferably the
22 ball is of a non-pliable material and thus cannot deform.
23 Advantageously the ball is made of steel.

24

25 According to a second aspect of the present invention
26 there is provided a downhole tool for circulating fluid
27 in a borehole, the tool comprising a substantially
28 cylindrical body having a central bore running axially
29 therethrough, the body including at least one first port
30 arranged substantially transversely to the central bore,
31 a sleeve located within the bore, the sleeve including at
32 least one second port arranged transversely to the
33 central bore for discharging fluid from the central bore

6

1 when the first and second ports are aligned and
2 mechanical biasing means located between the sleeve and
3 the body to bias the sleeve in a first direction at which
4 the ports are misaligned, wherein the sleeve includes an
5 expandable ball seat and the tool further includes at
6 least one ball, wherein the expandable ball seat
7 releasably retains the ball to prevent fluid flow through
8 the sleeve and cause the sleeve to move in the reverse
9 direction relative to the body so that the ports come
10 into alignment.

11

12 Preferably the mechanical bias is a strong spring. The
13 spring may be helical, conical or the like. A strong
14 string will prevent the sleeve moving in the reverse
15 direction by fluid flow in the central bore.

16

17 Preferably the expandable ball seat includes a part
18 conical surface having an aperture therethrough.
19 Advantageously the aperture has a diameter less than a
20 diameter of the ball. Preferably the ball seat is made of
21 a flexible material, so that at a predetermined pressure
22 it flexes to release the ball. Advantageously the ball
23 seat is made of a metal so that the seat is not prone to
24 wear during use. The ball seat may comprise a spring such
25 as a disc spring.

26

27 Optionally the ball seat may be of a layered structure.
28 Preferably the layered structure comprises a plurality of
29 disc springs. Advantageously the disc springs are
30 arranged oppositely in the structure to provide flex.

31

7

1 Preferably the ball is spherical. More preferably the
2 ball is of a non-pliable material and thus cannot deform.
3 Advantageously the ball is made of steel.

4

5 Preferably the tool further comprises engagement means to
6 control relative movement between the sleeve means and
7 the body. Preferably also the mechanical bias biases the
8 sleeve against the engagement means.

9

10 Preferably also the tool includes ball collecting means.
11 The ball collecting means may be an element located in
12 the casing means to prevent passage of the ball through
13 the tool, but allowing passage of fluid through the tool.

14

15 Preferably said first and second ports are located
16 substantially perpendicular to a longitudinal axis
17 through the tool. More preferably there are a plurality
18 of said first and said second ports. Advantageously there
19 are three or more said first and said second outlets.
20 Preferably also said first and said second outlets are
21 spaced equidistantly around the body and the sleeve
22 respectively.

23

24 Preferably said engagement means comprises at least one
25 index pin located in a profiled groove. Preferably the at
26 least one index pin is located on the body and the
27 profiled groove is located on an outer surface of the
28 sleeve. In this way, an index sleeve is produced with the
29 groove determining the relative position of the sleeve to
30 the body. Advantageously the groove extends
31 circumferentially around the sleeve, thus the tool can be
32 continuously cycled.

33

1 Preferably also the spring is located in a chamber
2 created between the sleeve and the body. Advantageously
3 the chamber includes an exhaust port such that fluid can
4 enter and be dispelled from the chamber by relative
5 movement of the sleeve and the body.
6

7 According to a third aspect of the present there is
8 provided a method of actuating a tool in a borehole, the
9 method comprising the steps;
10

- 11 (a) inserting in a work string a tool including an
12 actuating mechanism according to the first aspect;
- 13 (b) running the work string and tool into a borehole,
14 with the tool in a first operating position;
- 15 (c) dropping a ball into the work string such that the
16 ball locates in the expandable ball seat and by
17 virtue of an increase in pressure on the ball,
18 forcing the sleeve to move and switching the tool to
19 a second operating position; and
- 20 (d) releasing the ball by expanding the ball seat and
21 returning the tool to the first operating position
22 as the mechanical bias acts on the sleeve.
23

24 Preferably also the method includes the step of catching
25 the dropped ball in the work string.
26

27 According to a fourth aspect of the present invention
28 there is provided a method of circulating fluid in a
29 borehole, the method comprising the steps:
30

- 31 (a) inserting in a work string a tool including an
32 actuating mechanism according to the second aspect;

- 1 (b) running the work string and tool into a borehole,
2 with the tool in a closed position wherein the ports
3 are misaligned and fluid flows through the central
4 bore;
5 (c) dropping a ball into the work string such that the
6 ball locates in the expandable ball seat and by
7 virtue of an increase in pressure on the ball,
8 forcing the sleeve to move and switching the tool to
9 an open position wherein the ports are aligned;
10 (d) discharging fluid from the ports; and
11 (e) releasing the ball by expanding the ball seat,
12 returning the tool to the closed position as the
13 mechanical bias acts on the sleeve.
14
15 Preferably the method further includes the steps of:
16
17 (f) dropping a second ball, identical to the first ball,
18 into the work string such that the second ball
19 travels locates in the expandable ball seat and by
20 virtue of an increase in pressure on the ball,
21 forcing the sleeve to move and switching the tool to
22 an open position wherein the ports are aligned;
23 (g) discharging fluid from the ports; and
24 (h) releasing the ball by expanding the ball seat,
25 returning the tool to the closed position as the
26 mechanical bias acts on the sleeve.
27
28 With the sleeve and back in the first position, the steps
29 (f) to (h) can be repeated any number of times.
30
31 Preferably also the method includes the step of catching
32 the dropped balls in the work string.
33

10

1 According to a fifth aspect of the present invention
2 there is provided a method of circulating fluid in a
3 borehole, the method comprising the steps:

4

5 (a) inserting in a work string a tool including an
6 actuating mechanism according to the second aspect;

7 (b) running the work string and tool into a borehole,
8 with the tool in a first position wherein the ports
9 are misaligned and fluid flows through the work
10 string;

11 (c) dropping a ball into the work string such that the
12 ball locates in the expandable ball seat and by
13 virtue of an increase in pressure on the ball,
14 forcing the sleeve to move into a second position
15 relative to the body wherein the ports are
16 misaligned and fluid flow is through the work
17 string;

18 (d) releasing the ball by expanding the ball seat,
19 moving the tool to a third position by virtue of the
20 mechanical bias acting on the sleeve wherein the
21 ports are aligned and fluid flows through the ports.
22

23 Preferably the method further includes the steps of:

24

25 (e) dropping a second ball, identical to the first ball,
26 into the work string such that the second ball
27 locates in the expandable ball seat and by virtue of
28 an increase in pressure on the ball, forcing the
29 sleeve to move the second position relative to the
30 casing wherein the first and second ports are
31 misaligned and fluid flow is through the work
32 string; and

1 (f) releasing the ball by expanding the ball seat,
2 moving the sleeve to the first position by virtue of
3 the mechanical wherein the first and second ports
4 are misaligned and fluid flows through the work
5 string.
6

7 With the sleeve and casing back in the first position,
8 the steps (c) to (f) can be repeated any number of times.
9

10 Preferably also the method includes the step of catching
11 the dropped balls in the work string.
12

13 An embodiment of the present invention will now be
14 described by way of example only with reference to the
15 following Figures, of which:
16

17 Figure 1 is a part cross-sectional view of a downhole
18 tool in a first position according to an embodiment of
19 the present invention;
20

21 Figure 2 is a part cross-sectional view of the downhole
22 tool of Figure 1 in a second position;
23

24 Figure 3 is a part cross-sectional view of the downhole
25 tool of Figure 1 in a third position; and
26

27 Figures 4(a)-(c) are schematic illustrations of an index
28 pin positioned in a groove of the tool of Figure 1 for
29 the first, second and third positions respectively.
30

31 Reference is initially made to Figure 1 of the drawings
32 which illustrates a downhole tool, generally indicated by
33 reference numeral 10, in accordance with an embodiment of

12

1 the present invention. Tool 10 includes a cylindrical
2 body 12 having an upper end 14, a lower end 16 and a
3 cylindrical bore 18 running therethrough. The body 12 has
4 a box section 20 located at the upper end 14 and a pin
5 section 22 located at the lower end 16 for connecting the
6 tool 10 in a work string or drill string (not shown).

7
8 The body 12 further includes four radial ports 24 located
9 equidistantly around the body 12. The ports 24 are
10 perpendicular to the bore 18.

11
12 Located on an inner surface 26 of the body 12 are two
13 opposing ledges 26, 28 used to limit axial movement of a
14 sleeve 30 located within the body 12. Sleeve 30 is sealed
15 against body 12 by o-rings 31a-d.

16
17 Sleeve 30 is an annular body which also includes four
18 radial ports 32 located equidistantly around the sleeve
19 30. The ports 32 are perpendicular to the bore 18. The
20 ports 32 are of a similar size to the ports 24 in the
21 body 12.

22
23 At an upper end 36 of the sleeve 30 is located an
24 expandable ball seat 33. A conical surface 38 of the seat
25 33 faces the upper end 14 of the tool 10. The conical
26 surface 38 is part of a disc spring 34 mounted at the
27 upper end 36 of the sleeve 30. A perpendicular portion 40
28 of the spring 34 sits proud of the inner surface 39 of
29 the sleeve 30. The spring 34 is placed in the first
30 direction such that it operates opposite to its typical
31 arrangement. Spring 34 may comprise a stack of disc
32 springs selected to provide the a deflection or flex in
33 structure at a desired pressure. Each spring is

1 alternately arranged in the stack. Disc springs, and in
2 particular disc springs formed from conical shaped
3 washers (sometimes referred to as Belleville washers) as
4 used here, are well known to those skilled in the art.
5 Such springs are available from, for example, Belleville
6 Springs Ltd, Redditch, United Kingdom. An advantage of
7 these springs is that they return to their original shape
8 following deflection.

9
10 Located between the outer surface 44 of the sleeve 30 and
11 the inner surface 46 of the body 12 is a space forming a
12 chamber 48. The upper edge of the chamber is formed from
13 a ledge 50 on the outer surface 44 of the sleeve 30. The
14 lower edge of the chamber 48 is formed from the ledge 28
15 of the body 12. A strong spring 52 is positioned within
16 the chamber 48 and compressed to bias against the ledge
17 50 of the sleeve 30. An exhaust port 54 is located
18 through the sleeve 30 at the chamber 48 to allow fluid
19 from the bore 42 to pass in to and out of the chamber 48
20 as the sleeve 30 is moved relative to the body 12.

21
22 Further an engagement mechanism, generally indicated by
23 reference numeral 56, couples the sleeve 30 to the body
24 12 and controls relative movement there between.
25 Engagement mechanism 56 comprises an index sleeve 58,
26 being a portion of the sleeve 30, and a matching index
27 pin 60 located through the body 12 towards the sleeve 30.
28 Index sleeve 58 includes a profiled groove 62 on the
29 outer surface 44 of the sleeve 30 into which the index
30 pin 60 locates.

31
32 Reference is now made to Figure 4 of the drawings which
33 illustrates the groove 62 of the index sleeve 58. The

1 groove 62 extends circumferentially around the sleeve 30
2 in a continuous path. The groove 62 defines a path having
3 a substantially zig-zag profile to provided axial
4 movement of the sleeve 30 relative to the body 12.
5 Indeed, spring 52 biases the sleeve 30 against the index
6 pin 60. The path includes an extended longitudinal
7 portion 64 at every second upper apex of the zig-zag.
8 Further a stop 66 is located at the apexes of the zig-
9 zags to encourage the index pin 60 to remain at the
10 apexes and provide a locking function to the tool 10. The
11 stops 66 are in the direction of travel of the pin 60
12 along the groove 62.

13
14 Reference is now made to Figure 2 of the drawings which
15 illustrates the tool 10 of Figure 1, now with a ball 68
16 located in the bore 42. Like parts to those of Figure 1
17 have been given the same reference numeral for ease of
18 identification. Ball 68 is located on the expandable ball
19 seat 33 and is sized to block the bore 42. In this way
20 the ball 68 is arrested and pressure builds up behind the
21 ball 68. This pressure moves the ball 68 and sleeve 30
22 together within the body 12 to the position illustrated.
23 At this point the spring 52 is compressed fully, this
24 being the maximum distance of travel for the sleeve 30.
25 Any additional pressure will now cause the disc 34 to
26 flex and release the ball to travel through the sleeve 30
27 and into the bore 18.

28
29 The ball is of a hard material which is non-pliable.
30 Ideally the ball is made of a metal such as steel.
31

32 Reference is now made to Figure 3 of the drawings which
33 illustrates the tool 10 of Figure 1, now with the ball 68

1 exiting the sleeve 30 into the bore 18. Like parts to
2 those of Figures 1 and 2 have been given the same
3 reference numeral for ease of identification. Body 12
4 includes a pin 70 located into the bore 18. Pin 70 is a
5 ball retainer pin which blocks the passage of the ball 68
6 through the bore 18. Ball 68 will come to rest at the pin
7 70 and therefore be retrievable with the tool 10. Pin 70
8 does not prevent the flow of fluid through the bore 18
9 and from the tool 10 into the work string below. The pin
10 70 and the space 72 in the bore 18 immediately above it
11 may be considered as a ball catcher.

12
13 In use, tool 10 is connected to a work string using the
14 box section 20 and the pin section 22. As shown in
15 Figures 1 and 4(a), the spring 52 biases the sleeve 30
16 against the index pin 60 such that the pin 60 is located
17 in the base apex of the groove 62. This is referred to as
18 the first position of the tool 10. In this position,
19 sleeve ports 32 are located above body ports 24, thus
20 preventing fluid flow radially through these ports due to
21 their misalignment. All fluid flow is through bores 18, 42
22 of the tool 10. The tool 10 is then run into a bore hole
23 until it reaches a location where cleaning of the bore
24 hole casing or circulation of the fluid through the tool
25 is required.

26
27 Drop ball 68 is then released through the bore of the
28 work string from a surface. Ball 68 travels by fluid
29 pressure to the conical surface 38 at the upper end 36 of
30 the sleeve 30. The ball 68 lands on the seat 33 where its
31 progress is arrested. As the ball 68 is now blocking the
32 fluid flow through the bore 42, fluid pressure will build
33 up behind the ball and allow sufficient pressure to build

1 up on the ball 68 and sleeve 30 such that they can move
2 in the direction of applied pressure against the bias of
3 the spring 52. Consequently the sleeve 30 and ball 68
4 move to a second position. This position is illustrated
5 in Figure 2 and 4(b). The spring 52 is compressed into a
6 now smaller chamber 48. Fluid has been expelled from the
7 chamber 48 through the exhaust port 54. The index pin 60
8 is now located at the top of the longitudinal portion 64
9 of the groove 62. Consequently the sleeve ports 32 have
10 crossed the body ports 24 and are now located below them.
11 Fluid flow is thus still entirely through the bores
12 18, 42.

13
14 On increasing fluid pressure on the ball 68, with the
15 sleeve 30 now arrested, pressure is exerted on the ball
16 seat 33. The disc spring 34 will deflect under this
17 increased pressure and ejects the ball 68 into the bore
18 42 below the seat 33. The seat 33 will return to its
19 original shape. The ball 68 exits the seat 33 and free
20 falls from this point. The ball 68 travels by fluid
21 pressure until it is stopped by the pin 70 and is held in
22 the space 72. On release of the pressure, spring 52 moves
23 the sleeve 30 against the index pin 60 such that sleeve
24 travels to a third position. The third position is
25 illustrated in Figures 3 and 4(c). Fluid has been drawn
26 into the chamber 48 and this drawing and expelling of
27 fluid provides a hydraulic damping effect on the impact
28 on the pin 60. Index pin 60 is now located in an upper
29 apex of the groove 62 and the ports 24, 32 are aligned. In
30 this third position fluid is expelled radially from the
31 tool 10 through the now aligned ports 24, 32. The tool 10
32 is locked in this position by virtue of the stop 66 on

1 the groove 62 which prevents movement of the sleeve 30
2 for small variations in fluid pressure.

3
4 In order to close the ports 24,32, a second ball is
5 dropped from the surface through the work string. The
6 second ball, and indeed any ball subsequent to this, is
7 identical to the first ball 68. The second ball will
8 travel to the conical surface 38. On the build up of
9 fluid pressure behind the ball 68, the ball 68 and the
10 sleeve 30 will move downwards against the bias of the
11 spring 52. Consequently the index pin 60 will be
12 relocated into the next longitudinal groove 64 of the
13 groove 62 and thus the tool is returned to the second
14 position. When the second ball is released from the
15 expandable ball seat 33, the pin 60 and sleeve 30 will
16 move relatively back to the first position and the second
17 ball will come to rest by the first ball 68. Effectively
18 the tool is reset and by dropping further balls the tool
19 can be repeatedly cycled in an open and closed manner
20 as often as desired.

21
22 It will be appreciated that although the description
23 refers to relative positions as being 'above' and
24 'below', the tool of the present invention can equally
25 well be used in horizontal or inclined boreholes and is
26 not restricted to vertical boreholes. Additionally the
27 term 'borehole' can be used to refer to an open, cased or
28 lined well bore.

29
30 The principal advantage of the present invention is that
31 it provides an actuating mechanism which can be
32 repeatedly operated in a downhole tool. Further the
33 mechanism allows use of a metal ball instead of a

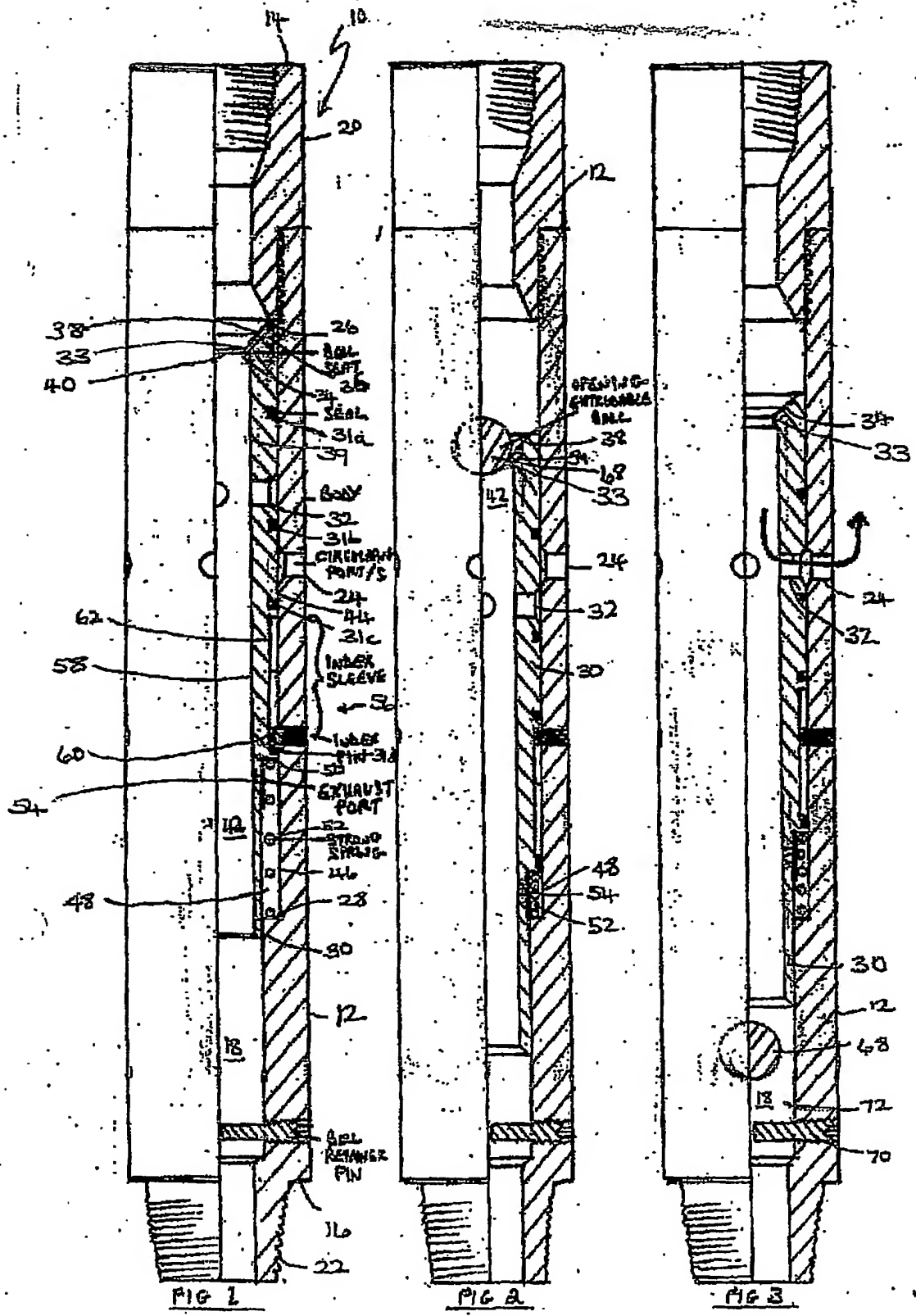
1 deformable ball. In this way pumped fluid flow is not
2 required to land the ball in the seat and thus the tool
3 can be operated without the need to pump.
4

5 Further an embodiment of the invention advantageously
6 provides a downhole tool for circulating fluid in a
7 borehole which can be repeatedly operated by dropping
8 identical balls through the work string. A further
9 advantage is that the tool can have any number of radial
10 ports to increase the flow area if desired compared with
11 the prior art.
12

13 Further as the actuating mechanism is located above the
14 ports, the ports are opened with no flow going across the
15 seals. This effectively saves the seals from excessive
16 wear. An additional advantage is in the ability of the
17 index sleeve to lock the circulating ports in position
18 when aligned. Yet further the entry and exit of fluid in
19 the chamber for the spring advantageously reduces the
20 impact on the index pin via the hydraulic damping effect.
21

22 Various modifications may be made to the invention herein
23 described without departing from the scope thereof. For
24 example, two or more index pins could be used to provide
25 increased stability to the tool and distribute the load
26 on the pins. Additional radial ports could be located at
27 longitudinal spacings on the tool to provide radial fluid
28 flow across a larger area when the ports are open. The
29 ports may have varying diameters which may provide a
30 nozzle on the outer surface of the body to increase fluid
31 velocity.
32

1/2



2/2

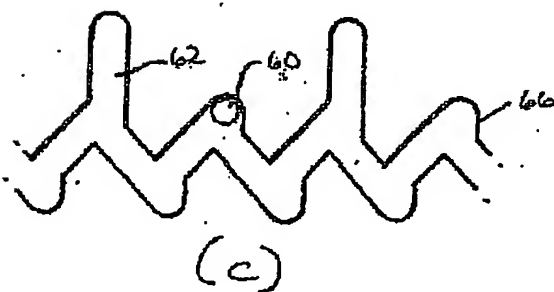
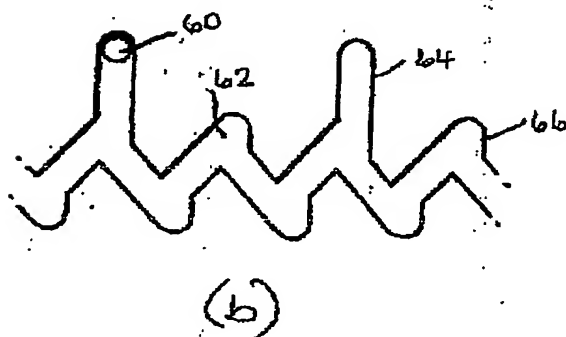
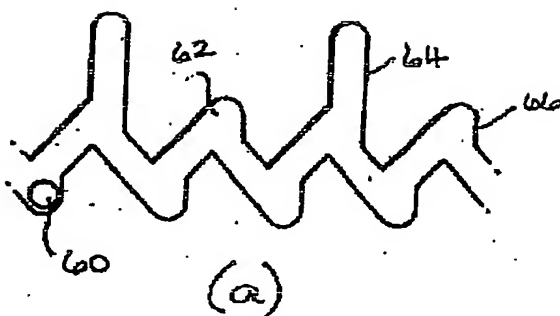


FIG 4